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ON THE DETERMINATION OF STELLAR MAGNITUDES BY MEANS OF PHOTOGRAPHY, BY DR. C. V. L. CHARLIER.

[The following extracts from a private letter to Professor HOLDEN are printed by permission of Dr. CHARLIER; and Professor SCHAEBERLE has added a brief commentary.]

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You will allow me to express my opinion as to your discussion of the determination of photographic magnitudes in No. 5 of your *Publications* (Vol. I, page 112), and to add a few words regarding the memoir of Professor SCHAEBERLE on the same subject (Vol. I, page 51). Against the fine method of Mr. SCHAEBERLE for determining the magnitudes of stars by photography it seems to me that the following remarks must be made:

1) . . . . The formula ($d = \alpha + \beta \log D + \gamma . D . \log t$) that he employs to express the relation between the dimensions of the star discs, the time of exposure and the aperture of the objective, is not suitable for general application. In fact it must be remembered that for the most of the instruments hitherto examined the diameters of the star-discs seem to increase proportionally to a certain power of the time of exposure. Now in all these cases I think the formula of Mr. SCHAEBERLE cannot be applied. Take for instance the instrument which I have employed in Stockholm in my photometric researches, for which I found the law (2) $d = d_0 \sqrt[4]{t}$. If we seek to determine the constants f and g in the formula of Mr. SCHAEBERLE $d = f + g \log t$ so as to satisfy the observed values of the diameters of *Polaris* (page 7 in my memoir), we obtain

$$f \; 21.6$$
$$g \; 43.3$$

and the different computed values of d as compared with the observed ones are given in the following table, where I have written down also the values, which follow according to the formula (2).

SCHAEBERLE:	22,	35,	48,	61,	74,	87,	100,	112,	125,	139
OBSERVED:	34,	41,	45,	56,	60,	78,	89,	108,	131,	156
CHARLIER:	33,	39,	46,	55,	65,	78,	92,	110,	131,	156

You find from this comparison that (2) almost completely reproduces the observations while the formula of Mr. SCHAEBERLE shows a distinct and systematic difference.

It is very interesting that photographic instruments seem to belong, in general, to two different classes. For one class the formula of Mr. SCHAEBERLE is the most suitable—for instance for the photographic telescope employed in the Lick Observatory or in Potsdam—for the other, and it seems the greater number, the increase of the star-discs proceeds proportionally to a certain power of the time of exposure. Is the cause of this anomaly to be sought in the different qualities of the plates employed? Or does it depend upon the objective? It seems to me that the theory of the development of the image is closely connected with this phenomenon.

2.) The other remark that I would make on Mr. SCHAEBERLE'S method is as follows: The application of (1) for the determination of stellar magnitudes requires us to assume that the brightness of the image of a star in the focus of an objective is proportional to the free aperture of the objective. Now this assumption is somewhat uncertain. Almost all observers, who have made researches in stellar photometry, have shown, that this proportionality only exists within narrow limits. For the ZÖLLNER photometer of the Observatory in Upsala, for instance, I have obtained (*Astrophotometrische Studien*, page 11) a difference greater than half a magnitude in applying the law in question by diminishing the aperture to the fifth of its original value. The application of the method of Mr. SCHAEBERLE to this instrument would accordingly be allowable only when the difference in stellar magnitude is very small (in maximum 1.5 magnitudes). Now this may be peculiar to the instrument in question, and the circumstances may be different for the instrument of Mr. SCHAEBERLE and perhaps more favorable. But the main point is that the proportionality of the aperture of the objective and the brightness of the image is somewhat doubtful. The difficulty can only be removed by a special research on the relation between these two factors for the special instrument employed in such investigations.

Finally, I venture to say a few words regarding your own proposal to establish a system for determining photographic magnitudes.* It now seems to me that the method proposed by you is in principle the best possible. In the research which I made on the brightness of the *Pleiades*, the circumstances were more favorable than in the general problem. Most of the stars being of the same spectral type it was *a priori* probable that the ratio between the photographic brightness of the different stars would, in general, be the same as the corresponding ratio of the visual brightness. When the question is no longer to determine the brightness of such a group of stars, but to establish a system of magnitudes for stars all over the heavens, I think it, if not necessary, at least desirable to do this to a certain degree independently of all visual evaluations of the magnitude. I use the expression "to a certain degree," meaning that the light ratio employed in determining the system of photographic magnitudes ought to be the same as that employed in visual photometry. From this point of view, I think that a combination of the methods employed by Mr. SCHAEBERLE and by myself will perhaps be sufficient to establish an absolute system of photographic magnitudes. With the method of Mr. SCHAEBERLE, which of course is somewhat troublesome to use in extensive series of observations, a sufficient number of "standard stars" is first to be determined. The remaining stars will then be very easily determined by the formula which I have proposed, having fixed for each plate the values of the constants *a* and *b* with the aid of the above-named standard stars.

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* See *Publ.* A. S. P. Vol. I. page 119.

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C. V. L. CHARLIER.

OBSERVATORY OF UPSALA, April 6, 1891.

Note on the above Letter.

With reference to the above letter from Dr. CHARLIER, I desire to make a few remarks.

I entirely agree with Dr. CHARLIER that the comparison given above shows that the formula to be employed in the reduction of the photographs must be that one which is deduced from the results obtained with the particular instrument and plate employed in the photographic work.

In my paper, referred to by Dr. CHARLIER, I expressly stated that the final equation represented the observed diameters on a No. 26 SEED plate in the focus of the particular telescope used.

With reference to the statement "The application of (1) for the determination of stellar magnitudes requires us to assume that the brightness of the image in the focus of an objective is proportional to the free aperture of the objective," I wish to say that while the remarks made on page 57 of my paper would naturally lead to such a conclusion, still such is not necessarily the case as I shall now attempt to show.